

AMENDMENTS TO THE SPECIFICATION

Please delete the present Abstract of the Disclosure.

Please add the following new Abstract of the Disclosure:

A vehicular headlamp employing a light-emitting element such as an LED and having an improved projected light pattern. A light-emitting surface of a light-emitting system has a horizontally elongated shape when viewed in a direction orthogonal to the optical axis of the light-emitting system so as to form a light distribution pattern which is enlarged through an optical system mainly in the horizontal direction. Since the projected pattern is obtained by enlarging the horizontally elongated light source image, it is easier to design the light distribution of the lamp in comparison to a case where the light intensity distribution of the light-emitting system is rotationally symmetric.

Please amend the following paragraphs:

[0006] However, there is a problem concerning the formation of a desired headlamp light distribution since the pattern of light emitted by a conventional light-emitting ~~element-system~~ has a substantially circular shape when viewed in the direction of the optical axis. For example, in the case of low-beam light, it is difficult to obtain a clear cut line (or cut-off line) that defines a constant boundary.

[0008] According to the present invention, a vehicular headlamp employing semiconductor light-emitting elements as a light source and having an optical system including a reflector or a lens is configured as described below. ~~The A~~ light-emitting ~~system element~~ may be provided with one or more semiconductor chips. There may also be provided a reflector, a fluorescent body and a lens. The light-emitting surface of the light-emitting ~~system element~~ is formed by the

surface portion of the semiconductor chip from which light emanates, and, if present, the surface portions of the reflector and fluorescent body which respectively reflect or emit light.

[0009] The focal point of the optical system (the focal point of the reflector or the object-side focal point of the lens, etc.) is set at or in the vicinity of the light-emitting surface of the light-emitting system element.

[0010] The light-emitting surface of the light-emitting system element has a horizontally elongated shape in the direction orthogonal to the optical axis when viewed in the direction of the optical axis of the light-emitting element.

[0011] Therefore, according to the present invention, since the light source image from the light-emitting surface having a horizontally elongated shape when viewed in the direction of the optical axis of the light-emitting system element is used, the necessity of a complicated optical design requiring distribution control by the optical system, as is the case when the light distribution is rotationally symmetric, is eliminated.

[0012] FIG. 1 is a cross-sectional explanatory view showing an example of the configuration of a light-emitting system element of a type which may be used with the invention.

[0013] FIG. 2 is a diagram showing an example of a rectangular light pattern produced by the light-emitting system element.

[0014] FIG. 3 is an explanatory diagram showing an example of the shape of a reflector and a semiconductor chip of the light-emitting system element when viewed in the direction of the optical axis.

[0020] FIGS. 9A and 9B schematically show in planar and perspective views, respectively, a light-emitting system element that has a plurality of semiconductor chips.

[0021] FIGS. 10A and 10B show in planar and perspective views, respectively, another example of a light-emitting system element that has a plurality of semiconductor chips.

[0022] FIG. 11 is a diagram schematically showing an example of the configuration of a headlamp according to the present invention, where the configuration is such that direct light from the light-emitting system element is used.

[0030] A light-emitting system element—1 is provided with a semiconductor chip 2, a reflector 3, a fluorescent body 4 and a lens 5. In this example, a light-emitting surface 1a is formed by those surfaces of the semiconductor chip 2, the reflector 3, and the fluorescent body 4 which emit or reflect light. The focal point of an accompanying optical system is set at or in the vicinity of the light-emitting surface. The “focal point” as used herein is not limited to the physically defined focal point of a reflector or a lens, but more broadly includes a data point or the like for optical form design.

[0032] A reflector 3 is formed in a member provided in the vicinity of the semiconductor chip 2. For instance, the supporting member of the semiconductor chip 2 can have a cup-shaped portion on which a concave face is formed, thus forming a reflecting surface. Light emitted from the semiconductor chip 2 has an orientation characteristic centered on the optical axis of the light-emitting system element. Thus, for a given distance from the semiconductor chip 2, the further an observation point is from the optical axis, the less the light intensity. Therefore, as shown in FIG. 1, between direct light 6a and reflected light 6b and 6c, the direct light in the optical axis direction is most intense. However, the reflector 3 is provided to effectively use light emitted toward the sides of the semiconductor chip such as light 6b. That is, light is reflected from the reflecting surface of the reflector 3 and directed forward (in the illumination

direction). Light 6c, emitted from the rear surface of a light-emitting layer of the semiconductor chip 2, is initially directed in the direction opposite to the illumination direction. However, light 6c is directed forward upon being reflected from the reflector 3. Alternatively, the light 6c can be radiated from a side face of the semiconductor chip 2 and reflected by the reflector 3 after being reflected from the rear surface of the semiconductor chip 2.

[0035] If a light source image of the light-emitting surface has a circular shape when viewed in the direction of the optical axis of the light-emitting system element, most of the light emitted from the light-emitting surface is direct light and contributes to the formation of the circular pattern. Further, a ring pattern located around the circular pattern is formed by light emitted from the sides of the lens, appearing thus as a pseudo light source.

[0037] Therefore, in a case where the light intensity distribution of the light-emitting system element is rotationally asymmetric around the optical axis, a structure is provided such that the light-emitting surface has a horizontally elongated shape along a direction orthogonal to the optical axis of the light-emitting system element, and thus the projected image through the optical system has a pattern shape with a straight portion.

[0038] FIG. 2 schematically shows an example of a pattern shape of a light source image of the light-emitting system element when viewed in the direction of the optical axis of the light-emitting system element.

[0042] To obtain the light source image described above, the semiconductor chip, the reflector, the fluorescent body, and/or the lens, namely, the members of which the light-emitting system element is composed, are designed to have a shape so as to produce a light source image which is rotationally asymmetric around the optical axis of the light-emitting system element. In

other words, the factors that determine the pattern shape of the light source image are the shape of the semiconductor chip, the shapes of the reflector or the fluorescent body, the shape and the material of the lens, and the optical and positional relationship among these components. Accordingly, it is possible to design a light-emitting system element—that has a desired light source image, employing simulation results using a combination of these elements (light ray tracing and light intensity distribution).

[0045] FIGS. 3 and 4 illustrate schematically examples of a semiconductor chip and reflector when viewed in the direction of the optical axis of the light-emitting system element. The semiconductor chip 2 in both cases has a square shape.

[0053] As mentioned above, a desired light source image of the light-emitting system element—can be obtained by appropriately designing the component elements of the light-emitting system element.

[0056] A variety of shapes can be obtained by combining some of the projected patterns of a light source image that is rotationally asymmetric with respect to the optical axis. For example, a pattern such as the light source image 14 can be obtained by combining two rectangular patterns. However, it is important to be able to obtain a light source image appropriate for the formation of the cut line using only one light-emitting system element—in terms of the ease of optical design of the low-beam light distribution. In other words, designing the reflector or the lens of the optical system becomes significantly easier if the pattern shape of the light source is designed taking the light distribution pattern into consideration from the beginning.

[0057] In this way, the design freedom of the lamp can be improved by employing light-emitting system elements—which produce a light source image that is appropriate for an

automotive headlamp beam pattern, and combining light-emitting elements according to the application at hand. Especially the design freedom is improved compared with the case of using only light-emitting system elements having a light source image with a given shape.

[0058] An explanation is given below concerning the light source image of a light-emitting system element appropriate for the formation of a projection light image pattern, using as an example a case where the light distribution pattern provided by the optical system is formed by combination of a condensed projected pattern and a diffusive projected pattern.

[0063] As shown in FIGS. 5 to 7, by using light-emitting system elements that have a separate light source image according to the function, projected patterns appropriate for a cut line of a low-beam light distribution, a hot zone (a light intensity center portion), a moderate degree diffusive area, and a large degree diffusive area are combined, and a desired light distribution can be obtained.

[0068] These patterns are formed as a collection of the projected images where the light source image of each light-emitting system element extends mainly laterally. Among the projected patterns 20, 21 and 22, the pattern 20 has the smallest diffusive characteristic, the pattern 21 has a diffusive characteristic of moderate degree, and the pattern 22 has the largest diffusive characteristic. Two or more (four, for example) types of light-emitting system element are used.

[0069] As described above, a preferable structure is such that a light-emitting system element for forming the intensive projected pattern, a light-emitting system element for forming the diffusive projected pattern, and a light-emitting system element for forming the cut line are

separately provided, and that each light source image has a different shape according to the light distribution function.

[0070] A structure in which a plurality of the light-emitting ~~elements~~ systems are used is not limited to a structure where one semiconductor chip is provided inside one light-emitting ~~system~~ element. For example, as shown in FIGS. 9A/9B and 10A/10B (respectively a plane view from above and perspective view from below), a structure is possible where a plurality of semiconductor chips are arranged inside the light-emitting system ~~element~~.

[0071] FIGS. 9A and 9B show an example of a structure where rectangular-shaped semiconductor chips 24 are arrayed in a given direction within a light-emitting ~~element~~ system 23. A fluorescent body or a transparent member 25 that has a semi-cylindrical shape covers these semiconductor chips. Otherwise, the transparent member may be arranged forward of a base plate provided with each semiconductor chip.

[0072] In this example, the size of the light source can be reduced, and an advantage exists in that there is no need to use a special optical system for the light-emitting system ~~element~~. This is achieved by arranging a plurality of the semiconductor chips on a side face (a cylindrical face) of a cylindrical member (a base material) and using a semi-cylindrical fluorescent body or transparent member, in comparison to the case where the structure is similar to a filament shape (a cylindrical shape as an ideal).

[0073] FIGS. 10A and 10B show an example of a structure where four rectangular semiconductor chips 27 are arranged inside a light-emitting ~~element~~ system 26. In other words, a two-line, two-row arrangement where the center of each semiconductor chip is located at each corner of a square or a rectangle is formed. A fluorescent body or a transparent member 28 may

cover these semiconductor chips, or the transparent member may be arranged forward of a base plate on which the semiconductor chips are mounted.

[0075] A problem can arise in the case where a plurality of semiconductor chips are provided inside a single light-emitting system element since the bonding wires used for electrical connection of the semiconductor chips can block light from the semiconductor chips so that a shadow of dark stripes may appear in the light source image. To prevent this, it is preferable to select electrode positions such that, to the extent possible, the bonding wires do not block the forward direction (illumination direction) of the semiconductor chip, or to adopt a structure where the bonding wires can be connected at lateral edges or faces of the semiconductor chip.

[0077] (A) a mode where direct light from the light-emitting system element is mainly used (FIG. 11), and

[0079] In a vehicular lamp 29 as shown in FIG. 11, an optical system (a projection optical system) 31 including a projection lens 30 is used. That is, in this example, a structure is provided where a light-emitting system element 32, a light-shielding member (shade) 33, and a projection lens 30 are provided, and the light-emitting system element 32 and the light-shielding member 33 are mounted on a supporting member 34. Further, the object-side focal point of the projection lens 30 is set close to the upper edge of the light-shielding member 33. It is preferable to set the upper edge portion of the light-shielding member 33 as close to the light-emitting system element 32 as possible for projecting the image formed by the partly shielded light from the light-emitting system element 32 at the upper edge of the light-shielding member 33.

[0080] The optical axes of the light-emitting system element 32 and the lamp are parallel. The output radiated light includes the light emitted by the light-emitting system element, namely,

the light directed forward as light 1 not blocked by the light-shielding member 33 located forward of the light-emitting system element, and passing through the projection lens 30. A cut line defining a contrast boundary in the light distribution pattern is formed by the upper end of the light-shielding member 33. With this arrangement, the greater the radiation angle of the light emitted from the light-emitting system element 32 the less light passes through the projection lens 30. Therefore, it is necessary to determine the radiation angle taking the diameter of the projection lens and its location into consideration.

[0081] In a vehicular headlamp 35 shown in FIG. 12, an optical system 38 including a projection lens 36 and a reflector 37 is used. That is, in this example, the lamp is provided with a light-emitting ~~element-system~~ 39, the reflector 37, and the projection lens 36, where a supporting member 40 for the light-emitting ~~element-system~~ 39 and the projection lens 36 is formed in a crank shape when viewed from the side, and a part of the supporting member serves as a light-shielding portion 40a. The focal point of the reflector 37 is set at or in the vicinity of the light-emitting surface of the light-emitting ~~element-system~~ 39, and an object-side focal point of the projection lens 36 is set in the vicinity of the light-shielding portion 40a.

[0082] The light-emitting ~~element-system~~ 39 is mounted on the supporting member 40 such that the optical axis thereof is orthogonal to the optical axis of the lamp. Most of the light emitted from the light-emitting ~~element-system~~ 30 is reflected from the reflecting surface of the reflector 37. After light directed forward without being blocked by the light-shielding portion 40a has passed through the projection lens, it becomes output radiated light. A cut line defining a contrast boundary in the light distribution pattern is formed by the upper edge of the light-shielding portion 40a. The light flux utility rate can be improved by providing a plane reflector

41 between the light-emitting ~~element~~system 39 and the light-shielding member 40a. It is possible to manufacture components of the optical system with greater accuracy regarding the mounting position of the light-emitting ~~element~~system 39, the upper edge position of the light-shielding member 40a, and the focal point of the projection lens 36, etc., by integrally forming the supporting member 40 and the projection lens 36 using a transparent material.

[0083] FIGS. 13 and 14 show schematically examples of a lamp according to mode (B), showing the positional relationship of a light-emitting system ~~element~~ 42, a reflecting surface 43, and a projection lens 44. FIG. 14 shows a vertical cross-sectional view, and FIG. 15 shows a lateral cross-sectional view. A light-shielding portion is not shown.

[0085] The light-emitting surface of the light-emitting system ~~element~~ 42 has a horizontally elongated shape in the direction parallel to the optical axis of the lamp. A projected pattern corresponding to the reflecting position on the reflecting surface 43 is obtained by the light source image of the light-emitting surface being enlarged via the optical system. The light distribution pattern is formed by the combined projected patterns.

[0089] All of these illumination units are configured as shown in FIG. 12, where the shapes of the light-emitting surface of the light-emitting system ~~elements~~ differ according to the light distribution function, and a focal point of the reflector, the light-shielding position, rear focus of the projection lens, etc., are designed according to specific purpose.

[0095] As evident from the above description, obtaining the desired light distribution pattern is easy with the use of the invention since the desired pattern can be obtained by enlarging with the optical system, mainly in the lateral direction, the light source image of a light-emitting surface which has a horizontally elongated shape when viewed in the optical axis direction of the

light-emitting system element. Further, the shapes and configurations of optical parts such as the reflector and the like are not made complicated since rotationally asymmetric light distribution is obtained around the optical axis.

[0097] A light source image having a desired light intensity distribution can be obtained by appropriately designing the shapes of a semiconductor chip, a reflector, and a fluorescent body that together form the light-emitting system element.

[0099] The degree of freedom in designing the light distribution can be improved by using light-emitting system elements according to distinct light distribution functions.

[0100] Overall size reduction can be achieved by arranging a plurality of the semiconductor chips inside one light-emitting system element, and a variety of light intensity distributions can be obtained by controlling individually which semiconductor chips are activated to emit light.